Introduction

This paper reviews and presents a critical analysis of two Canadian studies on the demand for intercity transportation services. The first (1971), a short take-off and landing aircraft service (STOL) set out to forecast consumer demand for a new transport service unit [6]. The second (1976), investigated ways of improving the passenger rail service in the Quebec City - Windsor corridor [7]. Both studies used new theoretical approaches to consumer demand for attributes [5] [2]; and employed for the first time, on such a grandscale, measurement techniques which attempted to forecast consumer preferences (trade-offs) among multi-attribute alternatives (options) [3]. Because of the growing interest and improved understanding of Lancaster's "New Approach" [5] and cojoint analysis (trade-off analysis) we believe some re-evaluation of these two studies is valid and useful to the marketing decision maker.

Before getting to the heart of the paper we will present some introductory details about the two studies, their respective research objectives, and the models selected to investigate these objectives.

Short Take-off and Landing (STOL) Study. This study was undertaken in 1971 [6]. Its general objective was to investigate the market research, analyses and forecasting requirement for a proposed STOL aircraft service between Montreal and Ottawa using Canadian Otters and DC-7s. More specifically, the major research objectives were to develop a model which would predict consumer acceptance of STOL air service, forecast the size of the STOL share of transportation market between those two cities; and evaluate the effect on its market shares and traffic volume that would result from various service designs resulting from systematic changes in certain characteristics, such as frequency, price, inflight service, etc.

Canadian Rail Transportation Study. This study was subtitled "A Method of Quantifying Travellers' Values for the Design of Optimal Intercity Transportation Systems." [7] The major object of the study was to design for management a strategy that would develop an improved rail service which would increase rail traffic and its model share in the Quebec - Windsor corridor, especially the Quebec City - Montreal, Ottawa - Toronto, and Toronto - Windsor routes. Again, management was interested in finding out how various service characteristics could be improved so as to arrive at a design that would maximize its appeal and satisfaction over competing services such as bus, conventional jet, automobiles.

Model Selection. The model selected by the researchers was dictated by the research objectives, i.e., forecasts of consumer preferences for various combinations of characteristics and/or attributes defining new transportation service or differentiation of the existing services. Since the approach was to design a new or differentiated travel mode that would optimize consumer satisfaction relative to other modes, the analysis required a methodology to search for the optimal design as well as a technique to measure the utilities derived from the attributes and characteristics that give such a design its uniqueness (demarcates it from other service types).

Johnson's trade-off analysis method was designed to investigate the research objectives. This methodology very crudely subsumes Lancaster's new theory of consumer demand in its procedures. Because of this the problems inherent in the New Approach also plagues the Johnson technique. We will briefly summarize this model and review some of its weaknesses, especially those relative to its predictive powers. Then we will outline the methodology employed by the two studies and proceed to do a critical analysis based on our critique of Lancaster's work.

The New Approach

Lancaster's new theory represents a restatement of consumer theory. In Lancaster's theory the consumer expresses his choice preferences in terms of collections of attributes rather than the collections of goods. A good is desired not for itself but because of its characteristics: demand for a commodity is, in Lancaster's sense, a derived demand. Having said that Lancaster proceeds to define consumer behaviour as efficiency oriented, that is, for any relative change in price the consumer will prefer more characteristics to less at a lower price. As the price of any given commodity decreases relative to all others, the consumer efficiency frontier changes independent of consumer preference. Therefore, in the general case[1] and for a given preference function the consumer will act to:

$$\text{Maximize} \qquad U(Z) \tag{1}$$

$$\text{subject to} \qquad Z = BY \tag{2}$$

$$X = AY \tag{3}$$

for $X \quad 0$; $PX = P(BY) = K$ (personal income)

Z is a vector of characteristics, and/or attributes

X is a vector of goods

Y is a vector representing levels of consumption activity

P is a vector of goods prices

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[1] Involving no 1:1 correspondence between goods and activities.

B is the consumer technology transformation matrix and A transforms the activities in goods space.

In the general case when B^{-1} exists by defining $Y^* = B^{-1}Z^*$, where Z^* the optimal vector of characteristics, one can identify the optimal goods vector X^* by substituting Y^* in equation (3). Z^* is the collection of characteristics which satisfy maximizers $U(Z)$.

Critical Review of the New Approach

Hendler [2] points out that in the Lancaster system it is really the consumption technology characteristics which are inputs used to produce outputs of utility and that the goods are the processes through which the outputs are obtained; we may identify the set of characteristics which has maximum appeal to us in an abstract sense but we must find the goods through which we can realize this utility. That is not always possible in practice, and therefore constitutes one of the major weaknesses of the new approach.

Rotchford [8] tells us that the theory breaks down under uncertainty. It cannot handle information, since implicit in the efficiency frontier concept of the model is the assumption of perfect information flow, and that the consumer will always make a diligent attempt to search for the optimum collection of goods. This is not likely to be so given the vast number of possibles he is confronted with and the imperfections of information.

The model tends to break down for other reasons more fundamental to its structure. Hendler tells us that implicit in the theory are two major assumptions on which Lancaster's notion of efficiency frontier rest. (1) The assumption that the consumer preference ratings (utilities) functions are independent of the characteristics-structure of his consumption unit (UIC or utility independence assumption), and (2) that the consumption unit (CU) can be obtained by mixing different combinations of goods (assumption of mixability of goods). The notion here is that the consumer may choose to mix different goods in order to arrive at the desired bundle of characteristics he wishes to consume per unit of time (CU).

Hendler presents several examples to show that these assumptions are not valid in practice; and presents mathematical examples to show that the theory breaks down. He concludes "no objective judgment is possible about the utility ranking of various bundles of characteristics when they are achieved through different linear combinations ....", the Lancaster efficiency frontiers are therefore really a "characteristics probability frontier". It represents a set of feasible collections some of which may or may not be optimums. This becomes even more painfully critical when researchers use the two-factor-at-a-time (take-off analysis) and full profile (concept evaluation) techniques to generate alternative multi-attribute options to the survey consumer. Roth [9] presents a much more rigorous and thorough critique of the efficiency frontier concept, especially as it has to do with the predictive power of the Lancaster model.

Roth seriously questions the predictive power of the model in a plausible decision environment. He raises this question around two issues:
(1) the tendency of the model to break down because of singularity in the B matrix
(2) the problems of "goods indeterminacy" resulting from problems of over and under identification of the structures in the model.
Roth argues that in any practical situation that there is a priori a great chance that two or more rows or columns in the B matrix will be linear combinations thus leading to singularity. Also using Lancaster's examples of the "simple society" and the "complex society" he shows that in any practical situation one may expect either a surplus of attributes over goods, or vice versa. A priori, therefore, one may expect a tendency for the model when applied in a real decision situation to be indeterminate. That is the optimal goods vector cannot be determined.

On the basis of these criticisms he concluded therefore that (1) the model is incapable of predicting that the consumer will undertake systematic effort to uncover a good or service embodying a bundle of characteristics for which no market analogue is readily available, and (2) within the constraints imposed by a rather plausible decision environment the model seems incapable of predicting the emergence of a new good, i.e., a goods that embody desired--but as yet unavailable--characteristics vectors.

Conjoint Analyses Methodology

Conjoint analysis is the term used "to cover models and techniques that emphasize the transformation of subjective responses into estimation parameters," i.e., utilities [1]. There are approximately six steps involved in the application of conjoint analysis. These are: 1) selection of preference model, 2) data collection method, of which there are two, i.e., two factors at a time (trade-off analysis) and full profile, 3) stimulus set construction applicable in the full profile method, 4) stimulus presentation, 5) measurement scales, and 6) estimation methods.

The method used by the two studies reviewed here is widely known as the Johnson's Trade-off Analysis method [3]. It measures the value systems of individuals from simple rank order or paired-comparison preference data.

Procedurally individuals in a sample representative of the market being analyzed are each presented with multiattribute alternatives from among which to choose. Inferences are then made about this value system based on (we hope) actual choice behaviour rather than upon verbally expressed preferences.

Both studies conducted preliminary studies to determine the attributes that were relevant to the analysis. They were as much as possible selected so as not to be interrelated. Between twelve and thirteen attributes were used. Some of these were trip cost, frequency of departure, baggage arrangements, personal comfort, length of trip, food and beverage service, etc. While conceptually identical the two studies are not strictly comparable because of differences in design of alternatives.

The STOL study used a trade-off analysis (two-factor-at-a-time) data collection procedure. The Rail Study used a partial full profile method. Both methods, however, by requesting the respondents to make choices between different combinations of service characteristics forced them to reveal their preferences. It should be noted here that no method exists to determine what combinations of characteristics should be used. This is a matter determined by computational convenience and the common sense of the researcher. Strictly speaking, therefore, one finds no attempt here to specify Lancaster's characteristics possibility frontier or consumer technology matrix (B).

Trade-off matrices representing selected pairs of attributes were constructed and presented to each respondent. The different trip designs represented in the cells were then ranked by each individual in the sample. Then Johnson's pairwise non-metric multi dimensional algorithm was used to derive each respondents utilities for all levels of each attribute. For each pair of attributes selected in a given trip design these utilities representing marginal probabilities were multiplied to derive the likelihood that a respondent will choose a trip with, say, "full mean service" and "trip costs of $8.00" over one with "no meals" and "trip costs of $8.00." Once this is iterated for all levels of costs and all levels of food and beverage services, a test of lack of fit between the actual rankings and the probabilities of the joint events in each cell is conducted to determine the internal consistency of the respondents preference behaviour. This is done by deriving a statistical measure phi (ϕ). This index has a value zero when there are no errors in the fit, and a value of one when the order of every pair of cells is incorrectly predicted [8].

Finally the utilities computed for each respondent were used to forecast usage and select optimal characteristics for any possible improved model service.

Overall utilities for each mode of transport were calculated for each respondent by asking the individual to consider trip situations which differ only for some particular attribute and the mode of transportation. These were then used to estimate relative likelihoods of using each mode. To determine the likely share of usage for a specific mode, each respondent's likelihood was then weighted by their trip frequency and cumulated to produce the share of preference over all respondents.

Having briefly stated the limitations of Lancaster's new approach to consumer theory; and summarized the methodology used to predict consumer preference behaviour and its effects on market shares when the consumer is confronted with differentiated service options, we now turn our attention to a critical examination of the two studies.

Critical Evaluation of the Two Studies

Given the state of the arts how well can STOL and the Canadian Rail Studies be said to have achieved their objectives, especially that of predicting market shares, on the basis of predictions of consumer preferences among multi-attribute options? Neither study makes the clear distinction between estimation of the curve fitting type; and forecasting (prediction) in the short term or long term sense, and these are important distinctions. Suffice it to say however that it would be misleading in the case of the Canadian Rail Study to claim that the results give any real test of the predictive power of the methodology.

It seems that what is being measured or estimated here is the amount of traffic that would switch from one mode to the other when changes are made in the level of service attributes pertaining to trips provided by a particular mode of transport. Here the behavior of the consumer seems to reflect his historical experiences since the changes he is asked to contemplate are within the range of existing experiences (one year back). The methodology does not present him with alternatives (options) outside his experience; nor is there anything in the methodology to suggest that the consumer do that search for himself when responding to a rather restrictive characteristics possibility frontier: he simply responds within the context of the options presented to him and one suspects within his historical experiences. Therefore, the data measuring the relative levels of the traveller's preference values for various service designs are historical. Moreover, it is relevant only in a fixed geographic and socio-economic environment. Projections of the observed patterns of consumer preference choices are, therefore, at best useful only in a very short term sense, and certainly not in a long term planning sense. One must conclude, therefore, that apart from useful insights into the structure of the existing transportation market, it offers little information that will be useful to the long term corporate planning function of the company.

In the STOL study a little more is attempted than in the Canadian Rail Study. Here we find some genuine pretentions to predicting consumer behaviour in a long term sense. The consumer is confronted with a new physical concept of a good embodying transportation characteristic similar to existing competitive modes, but at different levels. The question is, do the ratios of the attributes to each other make the structural form of this product uniquely different from conventional jet, train or bus? Is the consumer really being presented with a new product which embodies desired and potentially available characteristic vectors? We argue that the form of the product and the needs it satisfies are a subset of existing modes; it is not outside conventional travel experiences. We think that it is not sufficiently different from other forms as to really test the predictive powers of the model in a dynamic decision-making environment. The results of the STOL study seem to support our argument. A casual analysis of the market shares data suggests that consumers did not see the product as different from conventional take off and landing service (CTOL) so that the model exhibited no prediction power at all. This is, of course, consistent with Roth's arguments that, a priori, there are many situations in a plausible decision environment where two goods are perceived to be identical by some consumers in terms of the utility derived from specified characteristics. In such situations the B matrix does not have an inverse; consequently the model cannot predict consumer choice behaviour.

The results of the analysis show that there is no significant change in market shares of existing modes after the projected introduction of STOL.

Table 1: Market projection with STOL

	Original Projections	New Projections	
	Shares %	Shares %	Trips (000)
STOL	-	3.56	95
CTOL	4.22	3.33	88
Train	8.39	7.94	211
Bus	13.50	13.06	347
Auto	73.89	72.11	1919
	100.00	100.00	2660

Source: STOL, Analysis of Market, p. 84.

In fact the potential market for air travel seems to be split between the two modes STOL and CTOL indicating that whereas there is a market segment which demonstrates definite preferences for air travel between Ottawa and Montreal, that segment is indifferent or cannot differentiate between STOL and CTOL. Further evidence to this effect can be derived from the fact that the study shows that the sharpest differentiation of the product takes place when STOL has the additional service characteristic of a full bar service; STOL share almost doubles from 3.56 per cent to 6.70 per cent and does this largely at the expense of the automobile (see Table 2). This is an encouraging result.

TABLE 2: Introduction of Bar Service

	New Projections No Beverages on STOL Shares %	Modified Projections Full Bar Service on STOL Shares %	 Trips (000)
STOL	3.56	6.70	-83
CTOL	3.33	2.72	-15
Train	7.94	7.61	-8
Bus	13.06	12.61	-12
Auto	72.11	70.36	-48

Source: STOL, Analysis of Market, p. 86.

The model, however, does not permit us to conclude that this particular differentiation of STOL as a travel option is optimal to the consumer. While it is true, therefore, as the study claims the model appears to be at its best when used for the evaluation of marketing strategies (differentiation of products) on market shares it is not true to imply that the model succeeds in predicting consumer preferences with respect to new products by making the simple assertion that the "model has proved useful in forecasting demand for STOL" in the Montreal-Ottawa corridor. We maintain that STOL was never viewed as a distinctly new product in the given market structure: the use of Canadian Otters and DC-7s just represented the technology utilized to combine certain objective characteristics (i.e., capacity, flight flexibility, etc.). In this respect the study does not differ greatly from the Rail Study.

Even if we were to consider the product as a new product we would still be confronted with the problem of determining the optimal goods vector, since the methodology used has no procedures for determining the consumer technology which represents all possible multi-attribute alternatives; and therefore cannot permit of even an approximation of X* (the optimal good vector).

The methods for measuring levels of consumer preferences also compounds the problem of goods indeterminacy. Without becoming engrossed in a debate on the problems of measuring utility, we wish to point out that practice requires with conjoint analysis, whether using trade-off analysis or concept evaluation methods, that we limit the number of attributes and concept evaluation variations that we present to the consumer, thereby further increasing the tendency for good indeterminacy.

Moreover, the practical examples available to us to date reveal no indications and any rigorous theory (say, technological forecast methods such as Morphological analysis or DELPHI) has been used to arrive at feasible product differentiation possibilities and new product concepts. The same is true of the two studies reviewed on some ill defined theoretical possibility frontier. Selections from that set are the result of an arbitrary selection process determined by the research situation and convenience. It is doubtful if in those situations one can claim that sufficient of the postulates of consumer theory hold in order to justify the argument that in some sense individual utility curves have been identified and their parameters specified.

Claims that parameters derived from the model are internally consistent and valid refer more to the goodness of fit to an extremely limited attitudinal data set mapping experiences in a hypothetical as opposed to a real life situation. The gap between the theoretical response situation and the actual response is known to be often substantial.

Conclusion

We conclude that the two studies demonstrate that Lancaster's new theory of consumer demand provides an enlightening and refreshing theoretical frame from which analysis of how market strategies involving product differentiation can affect market shares of the commodities under analysis. It does this, however, under rather restrictive assumptions relating to the problems of measuring utility and the difficulties associated with selecting alternative product designs. Conjoint analysis does not resolve the problems associated with the specification of the consumer technology matrix, nor does it provide us with a method to select the best model to measure utility. For these and other reasons the studies do not present any evidence to support any claims that the theoretical constructs used can effectively predict consumer preferences for multi-attribute alternatives outside a limited range of the consumer's existing trip experiences (i.e., trips taken in the last year).

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